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Ramie Woven REINFORCED Epoxy Composite (RWREC): Tensile Strength Analysis

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ABSTRACT

Ramie woven reinforced epoxy composite has been sucessfully made for the application of ship's body hull. The use of natural fibers as reinforcement to the composite has been recently increasing; and it can be found at small-scale and large-scale industries. Some of the advantages of its use are eco-friendly, cheap, and having high tensile-strength. The aim of this research is to analyze the tensile-strength toward epoxy resin mixture in the woven ramie composite. The method employed is by testing the tensile-strength based on ASTM D638-02 type I standard. The result of this research shows that the highest tensile-strength is obtained in the mixture of Resin-Hardener 62-38, 60.45 ± 4.78 MPa, the fracture formed was brittle fracture and there was no pull-out or empty cavity; and the changing structure marked with the the formationof nitril functional groups (C ≡ N)with the sharp physical feature and medium intensity in the 2200-2400 cm^{-1} absorption area.

Key word : epoxi resin, hardener resin, tensile stress, ramie woven

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1. INTRODUCTION

The use of natural fibers as composite's reinforcement has been recently increasing, as it is used for the household utensils, and even in small-scale up to large-scale industries. The natural fibers have been, so far, used traditionally by the locals. Specifically in Sumbawa, they are used as bowstrings of traditional arrow by the indigenous (living in rural) of Indonesia; in Malaysia, they are used as riggings; in Papua, those who live nearby the beachesuse them as fishing lines and fishing nets because of its endurance within the seawater [1]. Due to its propensity to absorb water, the natural-fiber materials can be naturally decomposed by the fungi bacteria in a particular circumstance; that is why it is categorized into eco-friendly material. Besides its eco-friendly material, the natural fibers have several advantages, some of which are cheap price, high-mechanical strength especially tensile strength [2].

Agave cantula Roxb is one of the natural fiber's types which has high mechanical strength. This material is characterized as strong, light, durable, cheap, and also eco-friendly. The Board of Research and Industrial Development (Yogyakarta Industrial Department) has found that this material contains *cellulose* approximately 64.3% from which result proves possibility to use this material as the reinforcement's composite.

The adhesive epoxy resin is put into category that owns high reinforcement and endurance toward the environmental degradation.

Therefore, this resin is mostly used in the aircraft industry. As the coating resin epoxy, this resin also has a high adhesive and durability toward the water degradation; it is, thus, best to be used as boat's or ship's body hull [3].

Several research about the use of epoxy resin toward the natural-fiber composite have been conducted by using epoxy resin in order to analyze tensile-strength of laminate-bamboo fiber composite and woven by employing hand lay-up manufacture; and the proportion of epoxy resin with hardener is 1:1 [1], as well as using epoxy resin as the matrix in order to find out the effect of treatment over fiber's surface and the sea water submersion toward the physical and mechanical feature of *melinjo* (*genetum Gnemon*) rod fiber composite [4]. Another earlier research about the reaction of post curing toward tensile strength and micro stiffness with Vickers scale, mixing epoxy polymer DGBA and hardener *diamine* with several ranges of proportion namely 50:50, 60:40, and 40:60 [6]. A 4:1 mixing ratio epoxy resin with hardener is to find out the elasticity of *Arenga pinnata* fiber composite as the reinforcement and epoxy as matrix [7]. The 7:3 and 6:4 mixing ratio epoxy resin is to analyze the direction and treatment tap is fiber and ratio epoxy hardener toward the physical and mechanical feature of tap is epoxy composite [8]. A variation of 7:3 mixing ratio epoxy with hardener is to find out the mechanical feature of wood based on epoxy resin by using reinforced ramie fiber [8].

Epoxy resin has *hydrophobic* quality from which the natural cellulose fiber has ability to absorb water from unrestricted environment. The amount of water within the fiber affects the mechanical feature, which can reduce the adhesive between the fibers and the matrix polymer [9, 10]. The weakness of natural fiber characterized as *hydrophilic* has to be reduced in order to reach the compatibility with polymer resin, which is *hydrophobic*. The cellulose natural fiber will be very valuable if it is well processed due to its *hydrophilic* quality, which is applicable in the environment having limited amount of water. From the research, it can be concluded that the fixed value of various epoxy resin compositions has not been determined yet. Therefore, it will be very important to analyze them in order to obtain the best tensile strength.

2. RESEARCH METHOD

A. Material

The material used in this research was ramie yarn, *S 12/3* type. The ramie woven was produced by *Koppotren Darussalam* Garut, West Java. The ramie fibers were then selected from *Sentra Ramie Terpadu Koppontren Darussalam* Garut; and afterwards it was made into various types of woven namely Basket type ATM woven (woven machine); and the matrix used was *thermosetting* plastic such as epoxy resin (the mixture of resin and hardener) obtained from P.T Justus Kimia Raya, Semarang; and it was then made into a mixture of epoxy resin and hardener resin as many as 7 variations: they are 50:50, 55:45, 58:42, 60:40, 62:38, 64:36, and 67:33.

B. Tools

Molds made from steel with the size 25x25 cm, 30x30 cm, and 12x30 cm; measuring cups 500 ml, syringes 3ml, (to measure catalyst); thermometers, brushes and rolls, calipers, chainsaws, sandpapers, digital weighing scales, and electric ovens

C. Testing Tools

Tensile yarn and woven tools (SNI standard 08-0276-1989), tensile composite testing tool (ASTM standard D 638-02 type I), FTIR testing tool, and SEM-EDS testing tool are used in this research.

D. The Molding Process.

The process of molding composite used 250 mm x 250 mm steel plate. The steps of molding this composite specimen are: the tools and materials used should be prepared, the first step begins with pouring the resin and hardener into the measuring cup according to the determined mixing ratio, then mix the resin and hardener on a container; stir the mixture until it is spread evenly. Afterwards, pour the mixture of resin and hardener adequately into the measuring cup; then spread evenly into the measuring cup until they are all filled evenly. Leave them for 3 up to 5 minutes; cover with one layer of ramie woven and then pour the mixture again into the measuring cup. Cover the mold with the lid made from steel plate, and then press them with hydraulic press. This process is aimed to obtain a composite's standardized thickness. Wait for 6-8 hours until the mold is solidified. After they are all dry, the mold can be removed, (they are all still plates). The plates are then attached with pattern-drawn paper of tensile test, bending and impact based on ASTM standard (width, length, and thickness are all set appropriately), then cutting process uses chainsaw following the pattern drawn in the given picture; the result of the cutting is then finished by using sandpapers to smoothen the outer surface of the testing specimen. Afterwards, specimens are ready to be tested.

E. The Process of Tensile Yarn and Ramie Woven

The process of producing tensile yarn testing and woven specimens is according to the SNI 08-0276-1989 standard; there are 10 tensile yarn testing specimens having 600 mm length in size for each of them. For the woven, it is used 5 woven testing specimens with each size of specimen is 25 mm width and 300 mm length. These all were done in order to obtain a valid sample. By using Tenso-tensile-yarn machine, Tenso 300 type 168-E serial no.397 made in 1997, Salo-Italy.

F. The Process of Testing Tensile Composite

The process of producing tensile testing based on the ASTM D638-02 type I standard, with the width of narrow section (W = 13 ± 0.5) mm, length of narrow section (L = 57 ± 0.5) mm, width overall, min (Wo = 19 ± 6.4) mm, Length overall, min (Lo = 165) mm, Gage Length (G = 50 ± 0.25) mm, Distance Between Grips (D = 115 ± 5) mm, Radius of fillet (R =76 ±10 mm, Thickness (T) adjusted with the testing material.

The quantity of tensile specimens is 8. This is aimed to obtain valid samples. By using tensile testing machine namely *Go Tech Universal Testing Machine* model KT-7010A2, capacity 1000 Kg, produced by Kao Tieh Machinery Industrial CO., LTD, 1995.

3. RESULTS AND DISCUSSION

The tensile testing of ramie woven reinforced epoxy composite (RWREC) is aimed to find out the mechanical feature of a composite material reinforced by ramie woven. Beforehand, the tensile strength of a yarn is determined and the tensile strength of the ramie woven; the ramie woven taken from the samples of producing composite is Basket type ramie and the ramie yarn is S 12/3, and the average tensile strength is 32.41MPa (Figure 1), while the average tensile strength of woven is 19.72 MPa (Figure 2).

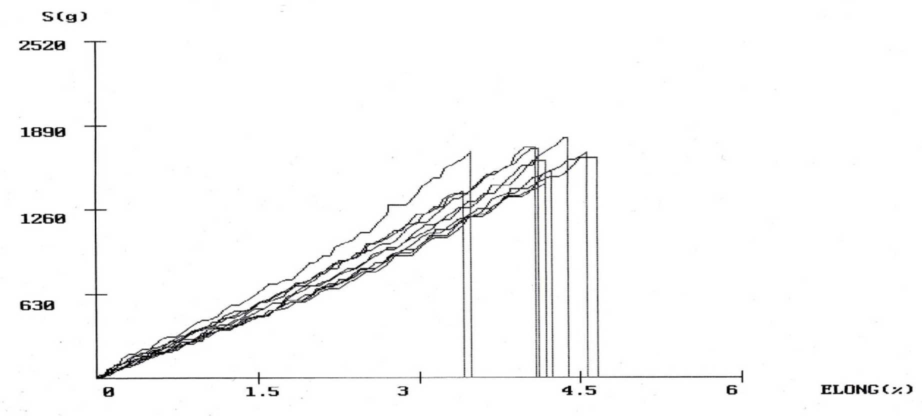

Figure 1. Ramie yarn tensile testing chart

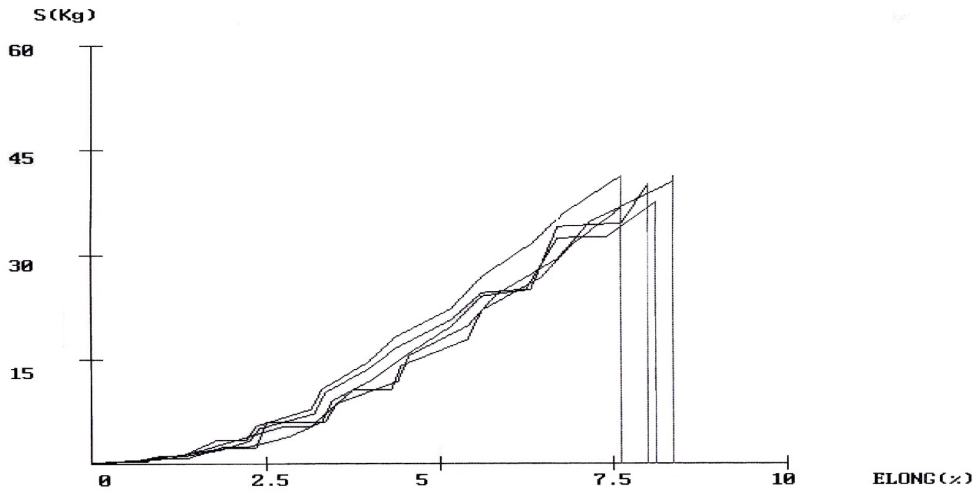

Figure 2. Ramie woven tensile strength ATM basket model chart

A. *FTIR Testing (FourierTransformatorInfra Red)*

On the FTIR spectrum, it is shown in the Figure 4 and 5. Figure 3 shown that absorption area 2200-2400 cm^{-1} are formed into nitril functional group **(C≡N)** or the picture (F) has more pointing physical feature and medium intensity (sharp and medium) within the mixture of epoxy resin and hardener resin (E). Whereas, the mixture of epoxy resin and hardener resin added with ramie woven will have medium intensity, of which characterizes the making of new material due to the enclosing cellulose. This case was also researched by Yin et al. [7] in order to find out the characteristics of lignin composite (epoxy+polyamida+lignin) with the ratio (1:0, 5:1). Rizkyta and Ardhyananta [11] researched the influence of adding carbon toward the mechanical characteristic with proportion of epoxy resin and polyamida (80:20:carbon and 20:80:carbon) by using FTIR as the functional group analysis material, which was formed.

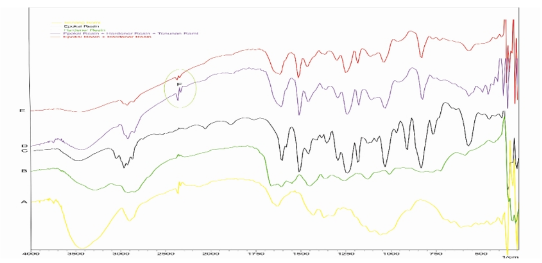

Figure 3. FTIR spectrum from A. ramie yarn (cellulose), B. Hardener resin, C. Epoxy resin (Polyamida) + ramie woven, E. Epoxy resin + Hardener resin, F. Nitril Functional group (C≡N)

On the figure no. 4 FTIR from various ratios of ramie woven composite is known that the 3300-3500 cm^{-1}absorption area is formed **O-H** group with widespread and strong intensity physical feature. The 2800-3100cm^{-1} absorption area is formed functional group **(-C-H)** aliphatic and **(=C-H)** aromatic with the sharp and strong physical feature. The 2200-2400 cm^{-1} absorption area is formed nitril functional group with sharp and strong intensity (sharp and strong). The 1600-1700 cm^{-1} absorption area is formed functional group **(C=C)** aromatic with the sharp and strong physical feature. At the area of fingerprint absorption is formed functional group **(C-O)** (sharp and strong) at the 956.69 cm^{-1} and functional group (C-N) (sharp and strong) at 825.53 cm^{-1}.

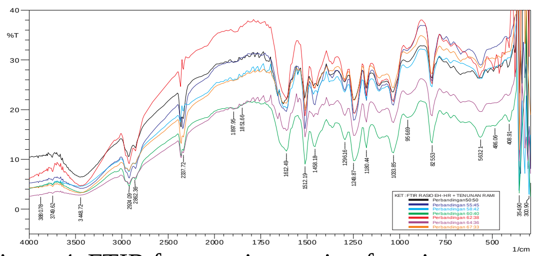

Figure 4. FTIR from various ratio of ramie woven

B. *The Composite Tensile Strength*

The chart of ramie woven reinforced epoxy composite (RWREC) tensile strength (Figure 5) with fraction volume of ramie woven fiber **(V_f)** 5.71 % from the RWREC ratio sample 50:50 up to 64:36, it is shown that the tendency of tensile tension value is increasing; although from the RWREC ratio sample 58:42 shows that the tensile tension value is decreasing compared with that of the RWREC ratio sample 55:4, this decreasing value is approximately 3,95% from the RWREC ratio sample 55:45.

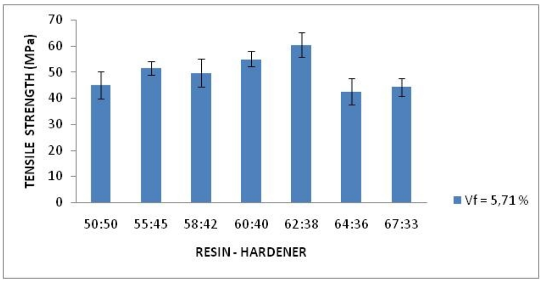

Figure 5. Ramie woven reinforced epoxy composite (RWREC) tensile strength chart

Whereas, the RWREC ratio sample 60:40 and 62:48 shows the increasing value of tensile tension, before it is finally decreasing from the RWREC ratio sample 64:36 and 67:33; therefore it can be concluded that the highest value of tensile tension is obtained from the RWREC ratio sample 62:38, that is 60.45 ± 4.78 MPa; and the lowest value of tensile tension is obtained from the RWREC ratio sample 64:36, that is 42.52 ± 5.01 MPa. The research done by Rochardjo et al. [6] found that the highest tensile strength is at the epoxy resin ratio 40:60 with the average value 62.5 MPa; and the fracture formed is brittle fracture. From the other research, done by Lokantara and Suardana [3] with the epoxy resin ratio 7:3 obtained tensile strength value 70.23 MPa; and the fracture formed is brittle fracture. Based on both of those research [3, 6], the fracture formed on the specimen is brittle fracture that give sigh tensile strength with the given epoxy resin ratio and with natural fiber reinforcement. It can be concluded that this research proved that the

highest tensile strength on the specimen fracture is brittle fracture with the RWREC mixing ratio 62:38 according to the figure no.6. Chart SEM, for the mixing resin-hardener 62:38,

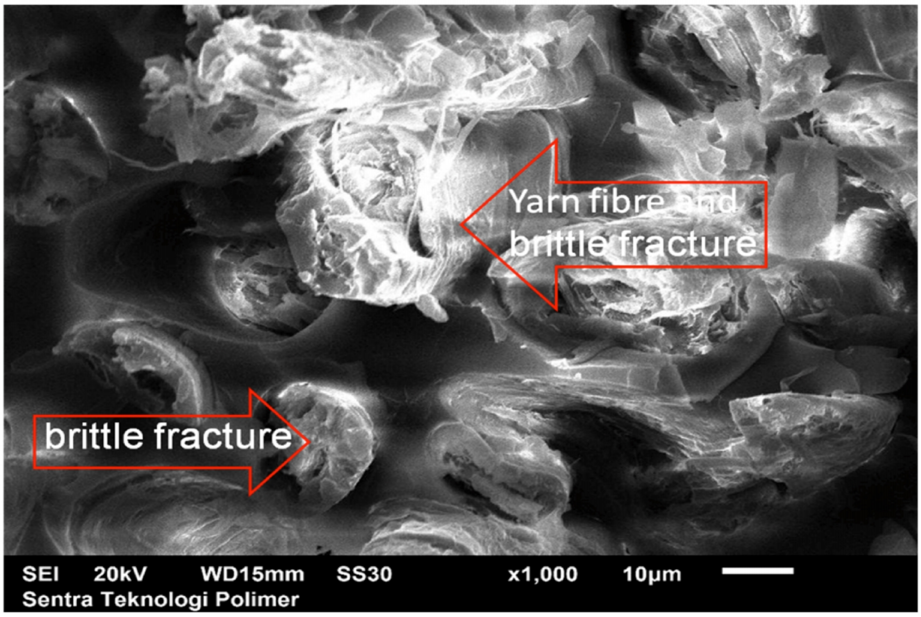

Figure 6. SEM chart for the mixing ratio resin-hardener 62:38

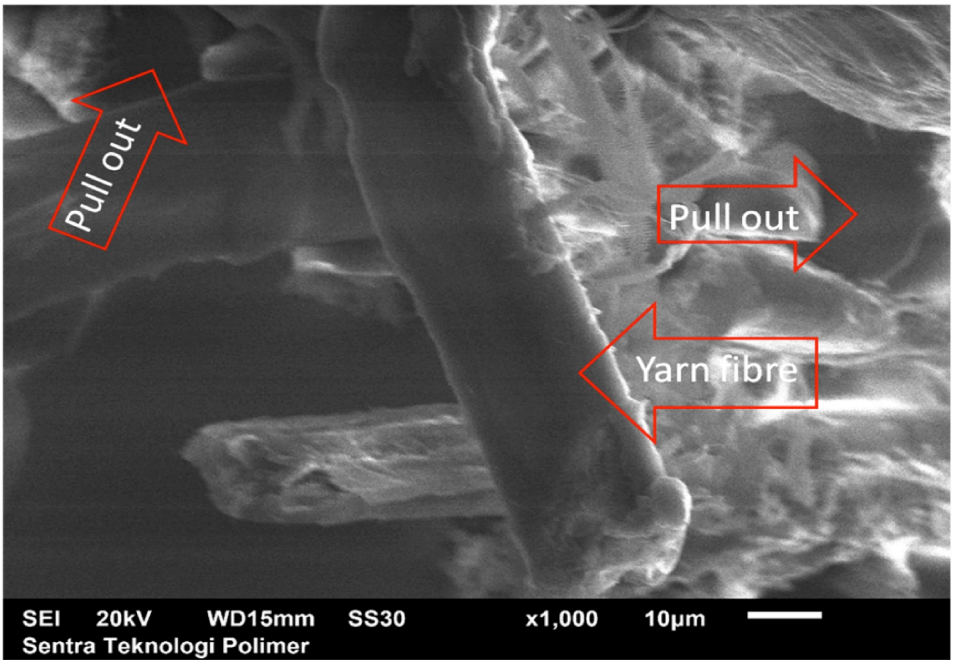

Figure 7. SEM chart for the mixing ratio resin-hardener 64:36

it is obviously seen that the fracture is brittle fracture and there is no pull out or empty cavity, whereas figure no.7 SEM, for the mixing resin-hardener 64:36 is clearly shown the ramie yarn fiber which is pulled out or made into empty cavity, there, thus, happened no brittle fracture.

C. SEM-EDS TESTING

From the result of analyzing SEM morphologically; that is composite testing specimens are cut into the size 0.5 x 0.5 cm, then coated with Aurum (Au) for 120 seconds at 20 kV voltage, therefore it is obtained composite SEM result shown in the picture no.6. Picture of SEM mixed with epoxy resin and hardener 64:36 added with ramie woven; it shows that ramie woven fibers are removed from its matrix or the pull-out and the empty cavities occurred due to the mixture of epoxy resin and hardener resin are not strong; this is also proved by the low tensile strength.

4. CONCLUSION

From the above discussion, it is concluded that the highest tensile strength is obtained in the mixing ratio resin-hardener 62:38, that is 60.45 ± 4.78 MPa; the fracture is brittle fracture and there is no pull out or empty cavity; and there is also changing structure with the forming of nitril functional group **(C≡N)** having sharp and medium intensity on the 2200-2400 cm^{-1} absorption area; whereas the lowest tensile strength is obtained in RWREC 64:36, 42.52 ±5.01 MPa.

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